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Manole A.M., Iliescu D.M., Rusali A., Bordei P.

Morphometry of the aortic arch and its branches

Discipline of anatomy, Department I – preclinical disciplines, Faculty of medicine, University "Ovidius" Constanţa

ABSTRACT

Our study was conducted by the evaluation of angioCT's performed on a GE LightSpeed VCT64 Slice CT Scanner. The measurements were performed on the aortic arch at the following levels: at the origin of the aorta, the middle part of the ascending aorta, prior to the origin of the brachiocephalic arterial trunk and after the origin of the left subclavian artery. We measured the caliber of the aortic arch arteries and the data are correlated and reported by gender. The diameter of the ascending aorta was between 27 to 28.9 mm in females and in males from 25.8 to 37.6 mm. The diameter of the aorta within the middle segment of the ascending part was between 28-30.2 mm in females and in males from 26.1 to 34.6. The diameter of the aortic arch prior to the origin of the brachiocephalic arterial trunk was between 26.4 to 29.4 mm in females and in males from 25.8 to 37.5 mm. The diameter of the aortic arch after the origin of the left subclavian artery was in a range of 20.4 to 28.4 mm, which corresponds to the limits found in males while in females the aortic diameter was between 21.3 to 24.1 mm. The brachiocephalic trunk diameters were 8.3 to 15.5 mm in females and in males was 9.1 to 14.5 mm. The right common carotid artery had a diameter of 4-8 mm diameter in males and in females ranged from 4.7 to 5.5 mm. The right subclavian artery showed a caliber of 5.7 to 7.5 mm in females and in males from 5.9 to 10.1. The left common carotid artery diameter was 4.6 to 5.7 mm in females and males the diameter was between 5.2 to 7.4 mm. The left subclavian artery had a diameter of 6-10 mm in females and in males ranged from 7.7 to 12.8 mm. We found that the distance between the ascending part of the aorta and the descending segment ranged from 33.3 to 38.5 mm in females and in males from 40 to 68.6 mm. We measured the distance that exists at the crossing of the aortic arch with the left branch of the pulmonary trunk, finding that in females this distance is 3 to 10.3 mm and in males from 3 to 12.5 mm.

Keywords: aortic arch - morphometry

Dr. Iliescu D.M.

Department of Anatomy, Faculty of medicine, University "Ovidius" Constanţa, Romania
Aleea Universitatii, Nr. 1, Campus B,
Constanţa, Romania
dan@anatomie.ro

Introduction

The aortic arch begins immediately after the aortic bulb and is oriented oblique posterior and to the left, passing from the anterior to the posterior mediastinum and crossing the lateral face of the tracheal bifurcation. Is located in a transverse plane and describes a double curve: one marked with the concavity oriented caudally and whose top reached, on average, 2.5 cm of the sternal notch and the other, less pronounced, with posterior concavity and to the right, neighboring the tracheo-esophageal axis [1]. Its position into the anterior and posterior mediastinum makes its surgical approach difficult and complex. It has four sides: anterior and left, posterior and right, superior and inferior. According to [2,3,4,5], at origin it goes obliquely anterior, superior and to the right, closer to the sternum and, after a 4-5 cm path recovers

to make an upward vertical direction; it inflects again, re-curving to become horizontal and posterior, at the left of the vertebral column. As a whole, it describes a very strong loop, whose ends are at a distance of 6-7 cm. The overall curvature of the aortic arch is dependent on the conformation of the thoracic cage, developing into more closer or less sagittal and frontal planes, thus describing sagittal or frontal types [4.6]:

- the sagittal type of aortic arch develops on a nearly sagittal plane and the curvature of its first portion, very little deep, always shows a large diameter; it only slightly exceed the median plane; this type occurs in young subjects and in adults with elongated thorax;

- in the frontal type, the aortic arch describes a curvature with the appearance of an elongated key frame, lying in the axial direction, of the smallest radius than the previous type, which contributes to the approach towards the frontal plane so that appears as a transverse expansion; it corresponds to the elongated radiological aorta; this type belongs to the aortic arch of elderly subjects or to the fat subjects, with broad and flared thorax.

Between these two extreme types, all the intermediate forms show a relative oblique aortic arch, closer to one of the foregoing types. The morphological type of the aortic arch strongly influences the origin of its branches. In the sagittal type, the arteries start together closer to the union between ascending and horizontal types. In contrast, in the frontal type, the arteries emerge from the horizontal portion of the aortic arch and diverge away from each other. In the first case, the arterial distribution is grouped (clustered type) and the origin of the vessels is separated by a spur [Cruveilhier, quoted by 5]; the left subclavian artery rise at the level of the top of the arch. In the second case, it is a dispersed type and a constant interval separates the origins of the great vessels. On the other hand, the left subclavian artery always arises posterior to the apex of the arch and the left common carotid emerges from this point.

Materials and methods

Our study was conducted by the evaluation of 33 angioCT's, 9 females and 24 males, performed on a sites readable GE LightSpeed VCT64 Slice CT Scanner. The measurements were performed on the aortic arch at the following levels: at the origin of the aorta, the middle part of the ascending aorta, prior to the origin of the brachiocephalic arterial trunk and after the origin of the left subclavian artery. We also measured the caliber of the aortic arch arteries.

Results

The diameter of the ascending aorta was between 25.8 and 37.6 mm; in females did not exceed 29 mm, being 27 to 28.9 mm and in males from 25.8 to 37.6 mm, with 12 cases between 25.8 to 28.4 and 12 cases with 32.4 to 37.6 mm (Figures 1 and 2).

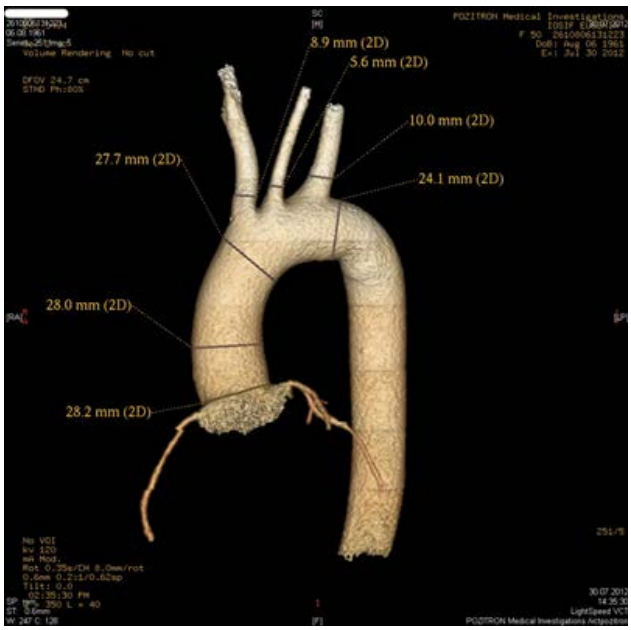

Figure 1 - Diameters of the aorta and of the aortic arch branches in female

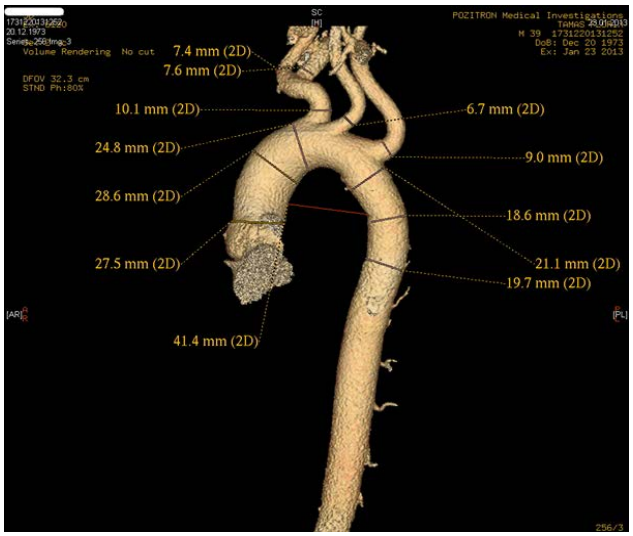

Figure 2 - Diameters of the aorta and of the aortic arch branches in males. Before the origin of the brachiocephalic trunk there is a decrease of the diameter with 6.2 mm. The aortic arch shows a span of 41.4 mm.

The diameter of the aorta within the middle segment of the ascending part was between 26.1-34.6 mm. In females it was 28-30.2 mm and in males from 26.1 to 34.6, with the following distribution: in 9 cases was 26.1-29.8 and in 15 cases it was 32.4-34.6 mm.

The diameter of the aortic arch prior to the origin of the brachiocephalic arterial trunk was between 25.8 and 37.5 mm. In females it was 26.4 to 29.4 mm and in males from 25.8 to 37.5 mm, with the following distribution: in 9 cases it was 25.8-29.4 mm, in 14 cases it was 30.7-33 mm and in a single case was 37.5 mm.

The diameter of the aortic arch posterior to the origin of the left subclavian artery was in a range of 20.4 to 28.4 mm, which corresponds to the limits found in males while in females the aortic diameter was between 21.3 to 24.1 mm (Figure 3).

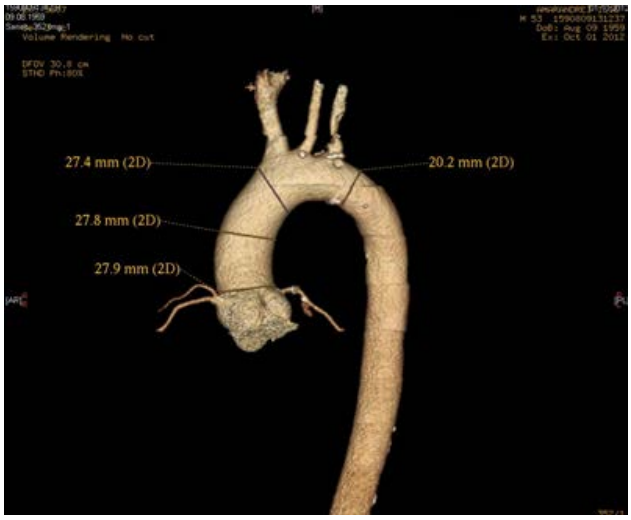

Figure 3 - A diminish of the aortic arch diameter with 5.2 mm

The brachiocephalic trunk diameters were 8.3 to 15.5 mm in females (a single case with 15.5 mm) and were 9.1 to 14.5 mm in males, with the following distribution: 9.1-9.8 mm in 10 cases, 10.8-11.2 mm in 7 cases, 12.2-12.7 in 6 cases and 14.5 mm in one case. The two arteries originating from the brachiocephalic trunk showed the following diameters: the right common carotid artery has a diameter of 4-8 mm in males while in females ranged from 4.7 to 5.5 mm. The male distribution was as follows: 4-4.5 mm in 7 cases, 4 cases with a diameter of 5.4 to 5.7 mm, in 12 cases it was between 6.1 to 6.9 mm and in one case was it 7.5 mm in diameter. The right subclavian artery showed a caliber of 5.7 to 7.5 mm in females and in males from 5.9 to 10.1 mm, with the following distribution: 5.9 to 6.6 mm in 6 cases, 7 to 7.8 mm in 7 cases, 7 cases from 8.2 to 8.4 mm, 9.6 mm in 3 cases and only one case in which the diameter was 10.1 mm.

The left common carotid artery diameter was 4.6 to 7.4 mm; in females it was 4.6-5.7 mm (4.6 mm for a left common carotid artery with brachiocephalic origin) while in males the diameter was between 5.2 to 7.4 mm, with the following distribution: in 9 cases was between 5.1 to 5.8 mm, in 11 cases ranged from 6.1 to 6.9 mm and in 4 cases the value was 7 to 7.4 mm diameter.

The left subclavian artery had a diameter of 6 to 12.8 mm, 6-10 mm in females and in males ranged

from 7.7 to 12.8 mm, with the following distribution: 9 cases ranged from 7.7 to 8.6 mm in diameter, in 6 cases was from 9 to 9.8 mm diameter, 8 cases had 10.2 to 11.4 mm diameter and a one case the left subclavian artery was 12.8 mm.

We found that the distance between the ascending part of the aorta and the descending segment ranged from 33.3 to 68.6 mm, with 33.3 to 38.5 mm in females and in males from 40 to 68.6 mm, with the following distribution: 9 cases 40 to 48.2 mm, in 12 cases the range was from 50.6 to 55.5 mm, and in 3 cases it was of 64 to 68.6 mm.

On 21 cases (9 females and 12 males), we measured the distance that exists at the crossing of the aortic arch with the left branch of the pulmonary trunk, finding that in females this distance is 3 to 10.3 mm and in males from 3 to 12.5 mm (Figures 4 and 5).

Figure 4 - The distance between the aortic arch and the left branch of the pulmonary trunk is 10.8 mm (female case).

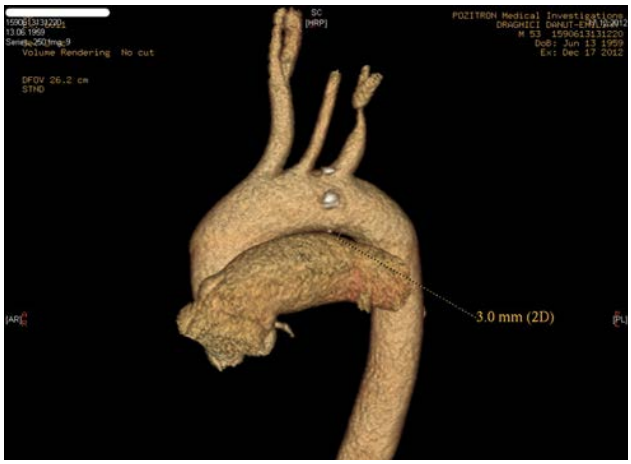

Figure 5 - The distance between the aortic arch and the left branch of the pulmonary trunk is only 3 mm (male case).

Discussions

The diameters of the ascending aorta, the aortic arch and the collateral branches of the aortic arch, with some small exceptions, do not show significant variations from one author to another (Table I).

As maximum diameter of the aorta at the origin, [8] finds 30 mm (without specifying the gender), while we found it lower in females (with 1.1 mm), but more voluminous in males (with 7.6 mm). The highest value of the diameter of the aortic origin is recorded by [1] and [9], with a value of 30 mm, [2] and [3] finding it with 2 mm less; we are finding it with 0.2 mm more in males females and in males with 4.6 mm. The maximum value of the diameter of the aortic arch origin before the origin of the brachiocephalic trunk, in females, was found with only 0.6 mm smaller than

Table I - The aortic diameters at origin, ascending aorta and aortic arch

Author		At origin	Asc. aorta	Orig. Asc. Ao.	Term Asc. Ao.
Nguyen		-	25-30mm	30mm	18-20mm
Testut		-	25-28 mm	-	18-20mm
Paturet		-	-	25mm	18-20mm
Gray		30mm	-	28mm	20mm
Bouchet		-	25-30mm	-	-
Gorun		-	-	28 mm	22mm
Personal cases	**F**	27-28.9mm	28-30.2mm	26.4-29.4mm	21.3-24.1mm
	M	25.8-37.6mm	26.1-34.6mm	25.8-37.5mm	20.4-28.4mm

Table II - Diameters of the aortic branches

Author		Brachiocephalic trunk	Left common carotid	Left subclavian
Paturet		13mm	9mm	9-10mm
Kamina		13mm	9mm	9-10mm
Bouchet		13mm	8mm	9-10mm
Shin Young		11.4mm	9.5mm	10.6mm
Testut		12-15mm	-	-
Turgut		-	13mm	-
Gorun		14mm	9mm	10mm
Personal cases	**F**	8.3-15.5mm	4.6-5.7mm	6-10mm
	M	9.1-14.5mm	5.2-7.4mm	7.7-12.8mm

[1], but higher by 1.4 mm than [10] and 4.4 mm than [4]. In males, the differences are greater by 7.5 mm to [1], and by 12.5 mm than [4]. Regarding the aortic diameter at the isthmus, the authors give a diameter of 20 mm, with the exception of [10] which gives it 2 mm larger; we found it in females greater than 2.1 mm [10] and larger with 4.1 mm than [1,2.3,4,8].

The maximum diameter of the brachiocephalic trunk level was 15.5 mm in females and 14.5 mm in males. As long as they were present in only one case each, we considered the value we got out just below this, in females being 9.3 mm and 12.8 mm for males. This shows that the brachiocephalic trunk diameter is smaller in females than in authors we refer with differences of 2.1 mm [11], 3.7 mm [4,6,7,9], with a difference of 4 7 mm [10] and a gap of 5.7 mm from [2,3]. In males these differences are smaller, being only 0.2 mm [4,6,7,9], lower by 1.2 mm [10], smaller by 2.2 mm [2,3], but larger by 1.4 mm [11].

The diameters of the left common carotid artery found by us are also lower than those reported in the literature, but this time with greater differences; the differences in females were less than 2.3 mm than [9], of 3.3 mm to [6,7,13], of 3.3 to 4.3 mm from [4] and 7.3 mm from [12], but we believe this is exaggerated. In males the minus differences are slightly lower than in females, with 1.6 mm [6,7,10], 2.1 mm [11], 1.6 to 2.6 mm [4], and again over the top of 5.6 mm [12].

The maximum diameters of the left subclavian artery in females are similar to the literature consulted, but there are differences in males, where we met differences from 2.8 to 3.8 mm [4,6,7,9], 2.8 mm [10] and 2.2 mm [11]

We found that, compared with the gender, the diameters of the aorta and of its arterial branches are larger in male, with a difference ranging from 0.6 to 2.8 mm.

Conclusions

We noticed that there is a clear relation between the origin of the arterial branches and the diameter of the aortic arch. The difference in caliber of the aortic arch between the origin of the brachiocephalic trunk and the left subclavian artery may reach 11 mm [13]. We have found that these differences are 9.1 mm in males (for the maximum caliber) and 5.6 mm (for the minimum caliber). In females, these differences are 8.1 mm and 5.1 mm (for the maximum and the minimum calibers). The relative caliber of the arterial branches of the aortic arch depends on the position of their origin from the aortic arch: within the arches whose branches had their origins in the horizontal segment, the first branch was the largest; when the branches emerged from the ascending segment, the thickest was the third branch [13]. The results confirm that there is a wide range of available anatomical variations of the aortic arch.

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